The Systematics of *Culex vishnui* Complex in Southeast Asia with the Diagnosis of Three Common Species (Diptera: Culicidae)[1]

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ABSTRACT. The concept of the *Culex vishnui* complex in Southeast Asia is reviewed with a primary objective to clarify the definition of the group with respect to its species composition on the basis of the morphology of all stages. With this revised interpretation, it should be better to recognize this complex as a subgroup of the *Sitiens* Group and to subdivide this subgroup into 3 complexes as follows: (1) *vishnui* complex *(sensu stricto)* with *vishnui* (including *annulus* form in Southeast Asia), *pseudovishnui* (including *neovishnui* form), *perplexus, alienus* and *incognitus;* (2) *tritaeniorhynchus* complex with *tritaeniorhynchus* and its infraspecific form *summorosus* and (3) *whitei* complex with *whitei* and probably one other infraspecific form. A summary of the diagnostic characters of *vishnui, pseudovishnui* and *tritaeniorhynchus* and a brief discussion of their current status is provided.

INTRODUCTION

The Southeast Asian *Culex vishnui* complex has attracted much attention because of its importance as actual or potential vectors of Japanese encephalitis virus and related arboviruses. In studies on virus isolation, laboratory transmission of arboviruses and feeding behavior, problems are frequently encountered which center around the identity of the adults of the various forms. The adults of these species are extremely similar, show considerable variation and overlap with one another. Thus, the separation of species are very tenuous and positive identifications are often impossible. Furthermore, in nearly all localities of this region, the complex is frequently represented by at least 3 species which occur in the same breeding site or habitat, especially in open cultivated lands such as rice fields and native plantations. The blood feeding habits of these species are also similar. Their preferred hosts include cows, water buffaloes and pigs. They also attack man on occasion. Adults are usually collected outdoors while feeding on these domestic animals or resting in outdoor shelters and among cultivated plants such as sugar cane. The similarity in the morphology and the bionomics of the species in this complex pose a serious problem in attempting to assess their roles as virus vectors. The purpose of this paper is to outline briefly the taxonomic aspects of the species involved and to focus attention on the

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identification of the 3 common Southeast Asian species by providing a brief account of their current status and diagnosis.

SYSTEMATICS

The *Culex vishnui* complex is a composite of many specific and infraspecific forms which are extremely similar in the adults and male genitalia and are chiefly characterized by striking differences in the larval stages. The term "complex" is used in a broad sense as widely adopted by taxonomists and applied entomologists to imply a group of species which are more or less morphologically similar and largely overlap one another in both larval breeding habitat and in pattern of distribution. This categorical term corresponds well in theory and practice to the sibling species concept of systematic zoologists. The species involved in this situation apparently exhibit a complex and rather delicate relationship with one another either due to convergence or parallelism in evolution. Thus the members of this category may not be necessarily related or have a common origin. When sufficient evidence has been accumulated based upon both morphological and non-morphological data of the included species and also other species groups including annectant forms within the subgenus, conclusions can be made concerning the true affinities of members of this complex. This subject is discussed to show the trend of developing a revised concept of the *vishnui* complex.

The concept of the *vishnui* complex has undergone various stages of development which are rather confused and very elusive. Colless (1957) first defined the group in his work on the Malayan species which included 5 - 8 species and subspecies. These were: *pseudovishnui, annulus, perplexus, alienus* and *tritaeniorhynchus* subspecies *summorosus*. He referred to this aggregate of species as a group which apparently also included the typical Indian *vishnui* and *tritaeniorhynchus*. Colless' interpretation is rather close to my current definition for this complex. It should be added, that in this treatment, the separation of species is based upon fundamental differences in the larvae. Bram (1967) in his work on the Thailand forms, referred to this group as a subgroup of the *Sitiens* Group to which 8 species were assigned. This included: *alienus, annulus, barraudi, mimulus, perplexus, tritaeniorhynchus* and *whitei*. His treatment created some distortion to the concept of this complex. Except for the term "subgroup" and for relegating *summorosus* to a synonym of *tritaeniorhynchus (sensu stricto)* which I currently follow, Bram's classification is not clear and partially unjustified. The moot point is in placing *barraudi* and *mimulus* with this subgroup without a clear indication as to their affinity, thus obscuring the true relationships among all the various forms involved.

Since the publication of the works of Colless and Bram, 2 significant studies have been made concerning the description of a new species and the specific status of some species. One of these was by Lien (1968) in Taiwan, who described a new species *"neovishnui"* which was distinguished from *pseudovishnui* on the basis of differences in the length and number of branches of a single prothoracic hair (4-P) and the number of lateral hair tufts on the siphon of the larva. The other study was by Reuben (1969) in India, who re-

described all stages of typical *vishnui* and treated *annulus* (which is the dominant Southeast Asian species) as a synonym of this species. Although both recent works create much confusion in the nomenclature, they are actually of considerable importance in my current treatment of the specific status of *vishnui* and in the redescription of *pseudovishnui*. The present conclusions are that the Southeast Asian *annulus* can best be considered either as a subspecies of *vishnui* or as its geographic infraspecific form. Since I have only seen a small sample of typical Indian *vishnui* and as large reared series of *vishnui* specimens are lacking, it is best to treat *annulus* only as a form of *vishnui* without elevating the name *"annulus"* which would further confuse the status of this species. As for *"neovishnui"* described by Lien, it appears justified to regard it as nothing more than a synonym of typical *pseudovishnui*. This conclusion is based on an extensive comparison of material from throughout Southeast Asia, including Taiwan. Larval stages of *pseudovishnui* and *neovishnui* show much overlap in breeding sites and distribution; their morphological differences are subject to considerable variation without any correlated differences in all other stages. This synonymy is very well supported by the recent study by Matsuo and Ramalingam (1972) based on specimens from several areas in the Oriental region.

My interpretation of the *vishnui* complex is that it should be referred to as a subgroup (as in Bram 1967) and then subdivide this subgroup into 3 complexes. In doing so, the *vishnui* complex which I refer to throughout this paper becomes the *Vishnui* Subgroup. The 3 complexes in this subgroup and the alignment of species in each complex are as follows: (1) *vishnui* complex *(sensu stricto)* with *vishnui* (both typical and the Southeast Asian *annulus)*, *pseudovishnui* (both typical and *neovishnui* Lien), *perplexus*, *alienus* and the Philippine *incognitus;* (2) *tritaeniorhynchus* complex with *tritaeniorhynchus* and its infraspecific form *summorosus* and (3) *whitei* complex with *whitei* and probably one other infraspecific form which still remains to be recognized.

DIAGNOSIS OF THREE COMMON SOUTHEAST ASIAN SPECIES

The diagnosis given below is restricted to the 3 most common species whose adults frequently present a great problem in routine identification. These are: *vishnui*, *pseudovishnui* and *tritaeniorhynchus*. The remaining species in this group are apparently rare and seldom encountered except for the Philippine *incognitus* whose diagnosis by Baisas (1938) and Delfinado (1966) should be consulted. It should also be emphasized that positive identification of these species can readily be made by examining the adults with associated larval and pupal skins from individual field rearing. However, by incorporating an extensive larval survey and by a thorough analysis of species composition in a particular type of ground pool habitat, it should be possible to identify the wild caught adults of both sexes by using the combination of characters given below and as illustrated.

(1) *Culex vishnui* (Figs.1, 9). The adults of both sexes of *vishnui* can be identified by the following features: *Head:* Erect scales of vertex usually entirely brown, sometimes erect scales in center of vertex slightly pale yel-

low but not contrasting sharply with dark erect scales on lateral or posterolateral areas. *Proboscis:* With a broad pale ring in the middle, the rest completely dark, without scattered pale scales forming streak on ventral or lateral surfaces in basal 0.5. *Thorax:* Anterior 0.7 of mesonotum, from anterior margin to about the level of wing base usually covered with dark brown scales and with some mixture of pale golden or whitish scales; pale scales usually restricted to areas behind fossa and lateral margin of mesonotum. *Legs:* Anterior surface of hindfemur usually without distinct pale stripe or with slightly pale stripe not contrasting with dark scaled area on dorsal surface. *Abdomen:* Terga with relatively broad and even basal pale bands. *Female Cibarial Armature* (Fig. 10): Cibarial bar with a concave row of short, coarse and abruptly pointed teeth. *Male* (Fig. 9): Proboscis with a distinct ventral tuft of 5 - long hairs at base of median pale ring. Segment 3 of palpus with a row of very short flattened scalelike setae on ventral surface, these setae are about 1.0 - 1.5 times as long as segment width. *Male Genitalia* (Figs. 2, 11): Apical fingerlike processes of the phallosome strong and long, with its apices projecting well beyond apical margin of sternal spiculate portion. *Pupa* (Fig. 2): Trumpet yellow, with or without blackish tinge, but not brownish. Seta 8-C of cephalothorax usually double, rarely triple or more branches. Seta 1-II of abdomen with 4 - 10 branches or not strongly plumose; seta 6 of segments III-IV double or triple and seta 6 of segments V-VI with 3 or 4 branches. *Larva* (Figs. 3, 11): Thorax with a broad patch of numerous spicules (visible under 10X objective). Seta 7 of abdominal segment I single; segment VIII with a broad oval patch of several comb scales, all subequal in size and with apical fringe of spicules terminating into a strong median spine. Siphon slender, more or less straight, color usually yellow; 2 - 3 distal pecten teeth very strong, with prominent, curved, apical spine; siphonal hair tufts strong, 6 - 7 pairs, 4 - 6 proximal pairs form a single dense row on ventral surface.

(2) *Culex pseudovishnui*. The *pseudovishnui* adults (Fig. 9) can be easily confused with those of *vishnui*. Caution should be taken in using the following diagnostic features: *Head:* Color of erect scales in center of vertex pale, creamy or yellow white, contrasting rather sharply with black erect scales on lateral and posterolateral areas. *Thorax:* Scales on anterior 0.7 of mesonotum usually predominantly yellowish white, more or less contrasting with dark scales on posterior 0.3; sometime with dark scaled streak on acrostichal and dorsocentral areas. *Legs:* Anterior surface of hindfemur with very distinct white stripe from base to near apex. *Abdomen:* Terga usually with very narrow basal pale bands which are progressively decreased in width toward posterior segments. *Female Cibarial Armature:* Indistinguishable from *vishnui*. *Male* (Fig.9): Proboscis without distinct tuft of setae at base of median pale ring, sometime with a few short setae, not forming a strong tuft as *vishnui* or *tritaeniorhynchus*. *Male genitalia* (Figs. 4, 11): Not readily distinguished from *vishnui*. *Pupa* (Fig. 4): As figured for *vishnui*, differing particularly in the following: Seta 8-C of cephalothorax usually with 4 - 6 branches. Seta 6 of abdominal segments III-VI with 4 - 6 branches. *Larva* (Figs. 5, 11): Differing from *vishnui* and *tritaeniorhynchus* in the following: Thorax without spiculation. Hair 7 of abdominal segment I single; segment VIII of abdomen with 1 or sometime 2 irregular rows of 5 - 7 very

large spinelike comb scales. Siphon yellow, usually strongly curved upwards in apical portion; siphonal tufts 6 - 7 pairs, 5 - 6 proximal pairs form dense double rows subventrally.

(3) *Culex tritaeniorhynchus*. The adults of *tritaeniorhynchus* (Figs. 6, 9) are relatively small, generally reddish or deep chestnut brown and are apparently darker than those of *vishnui* and *pseudovishnui*. They can be readily separated from the latter 2 species as follows: *Head:* All erect scales of vertex dark brown. *Proboscis:* Median pale ring very narrow, about 0.10 - 0.12 of total length; basal portion usually with some pale scales forming streak adjacent to median pale ring; ventral surface with a pale scaled line extending from basal 0.2 - 0.5 or more of total length. *Thorax:* Scales on most part of mesonotum usually entirely dark brown except for pale scales in middle of prescutellar space. *Abdomen:* Terga with narrow basal pale bands which are broad in middle, narrow towards lateral areas. *Female Cibarial Armature* (Fig. 10): Cibarial teeth long, fine and distally filamentous. *Male* (Fig. 9): Proboscis with a strong ventral tuft of 4 - 10 long setae at base of median pale ring. Segment 3 of palpus with a row of fine, dark hairlike setae on ventral surface. *Male Genitalia* (Figs. 7, 11): Apical fingerlike processes of phallosome weak, short, with apices projecting slightly beyond apical margin of sternal spiculate portion of inner division. *Pupa* (Fig. 7): Trumpet dark brown, contrasting with underlying integument. Seta 8-C of cephalothorax with 5 or 6 branches. Seta 1 of abdominal segment II strongly dendritic or composed of more than 10 branches; seta 6 of segments III-IV with 5 or 6 branches. *Larva* (Figs. 8, 11): Thorax without spiculation. Seta 7 of abdominal segment I double; segment VIII with a broad oval patch of several comb scales, all small, subequal, apices rounded, with even lateral fringe of fine spicules. Siphon usually brownish, slender and straight; 2 - 3 distal pecten teeth with fine apical spine; siphonal tufts 5 - 6 pairs; widely spaced, 3 - 4 proximal pairs inserted subventrally.

As indicated earlier, the typical Indian *tritaeniorhynchus* and its infraspecific form *summorosus* are currently treated as a single variable species. Both forms show slight differences in the male phallosome but show practically no differences in all other stages.

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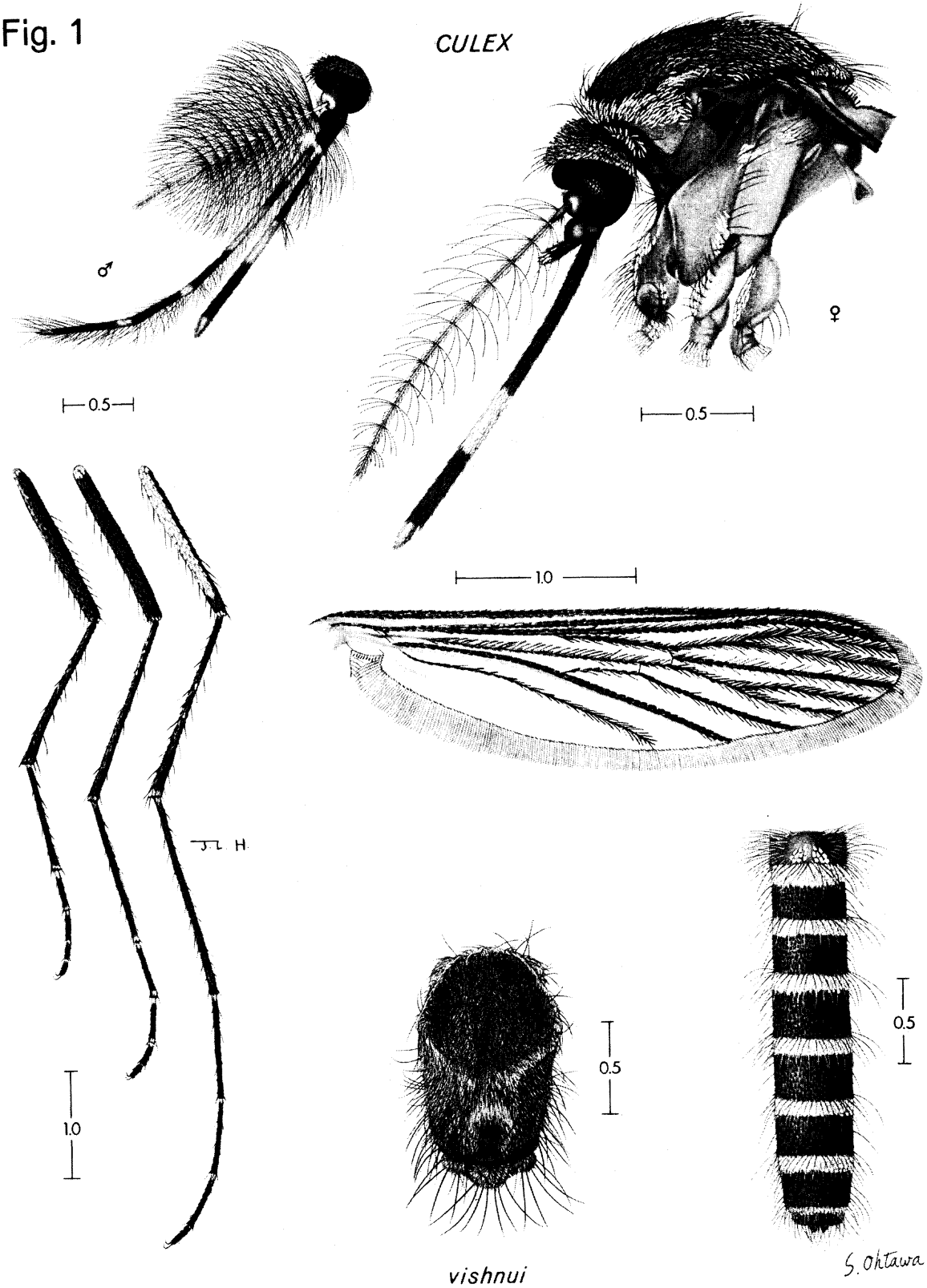
Fig. 1



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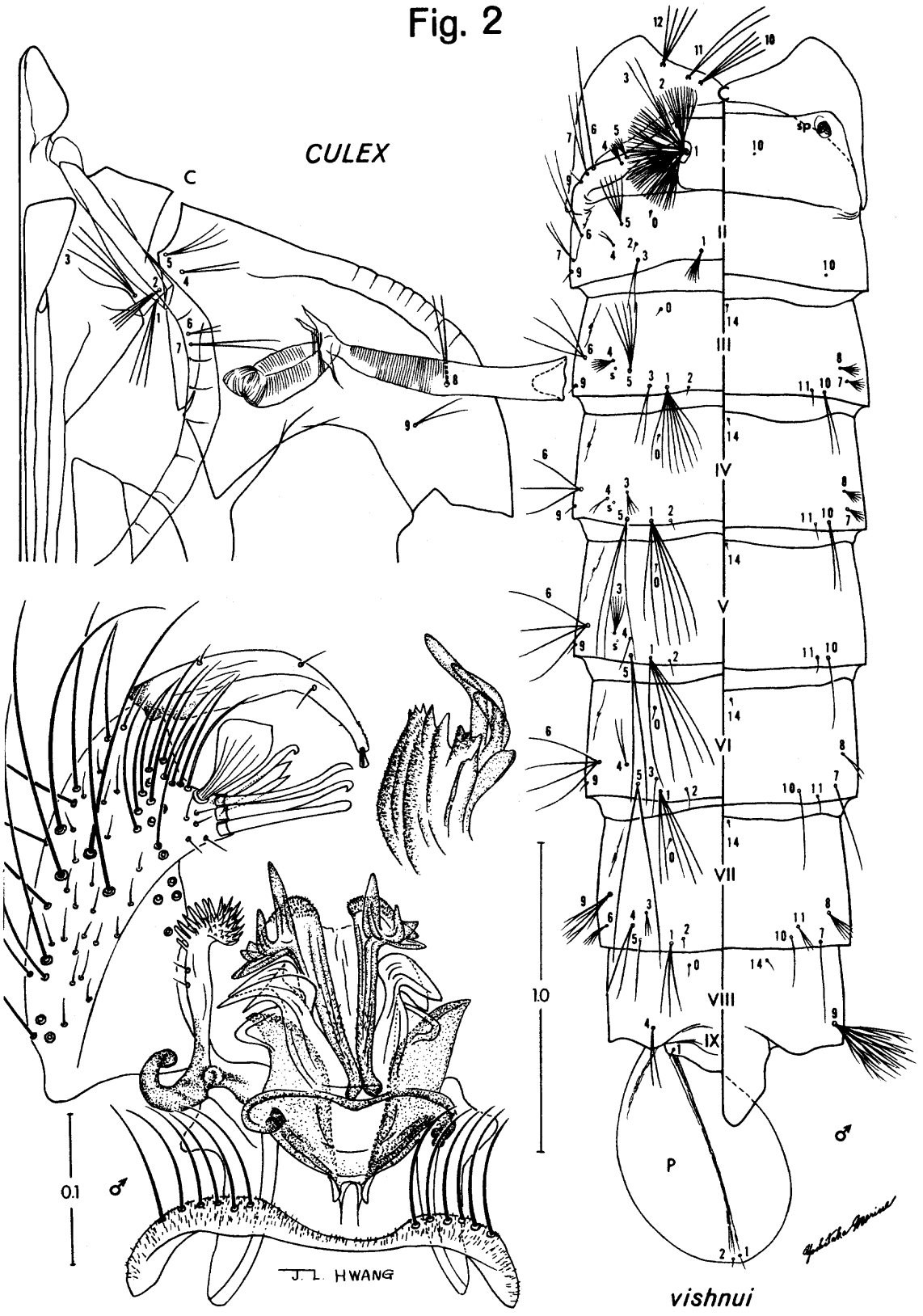

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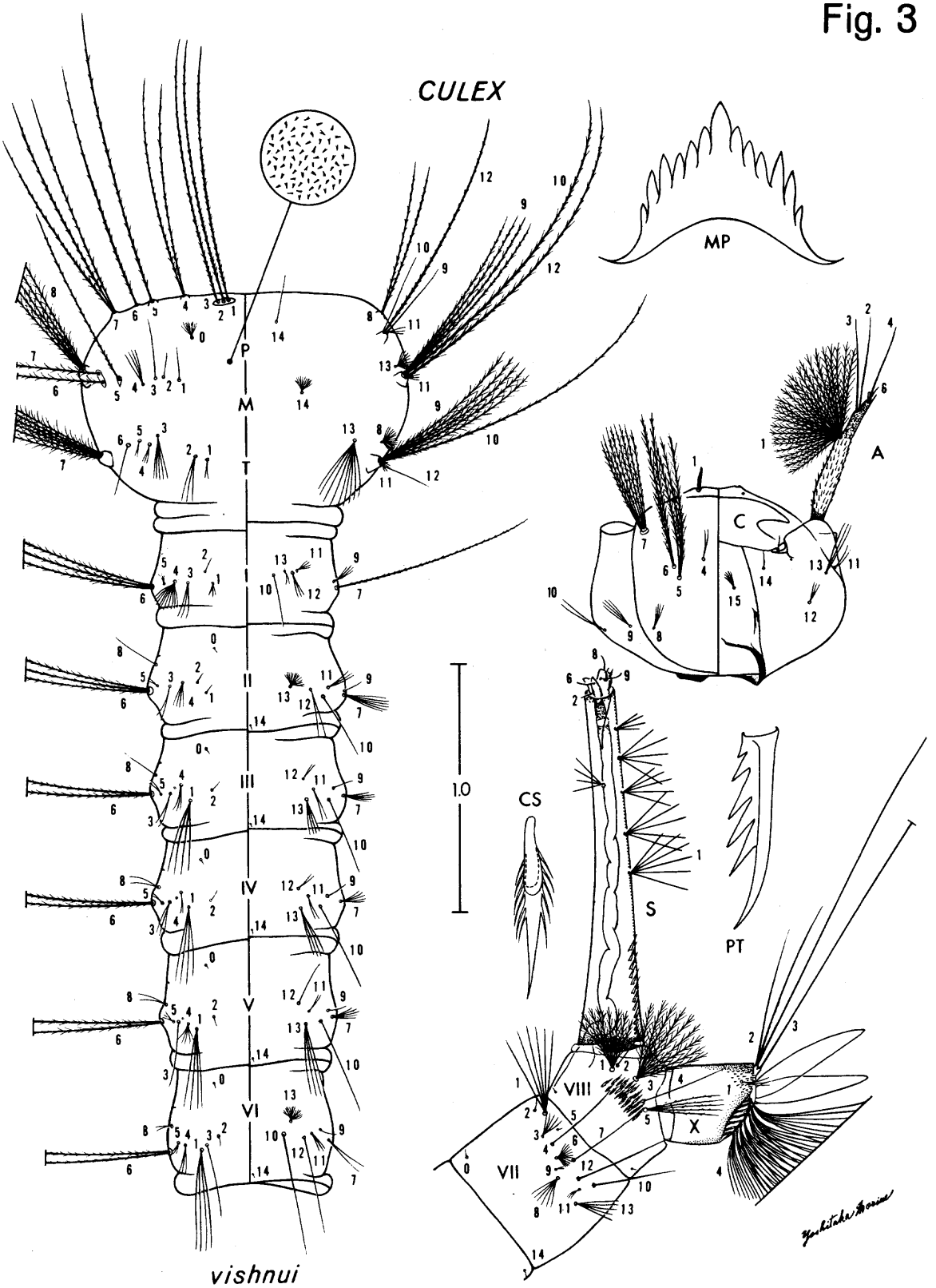

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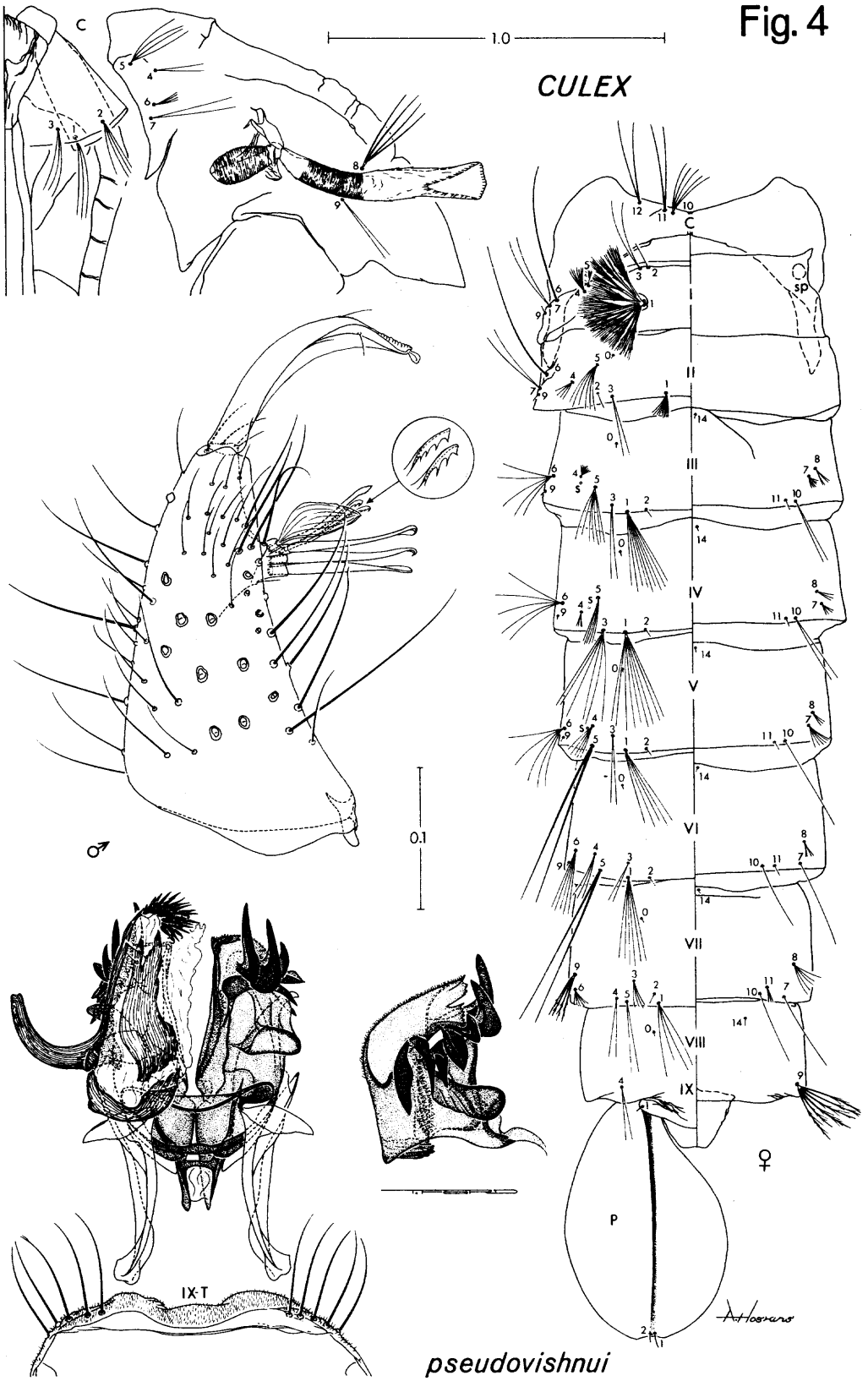

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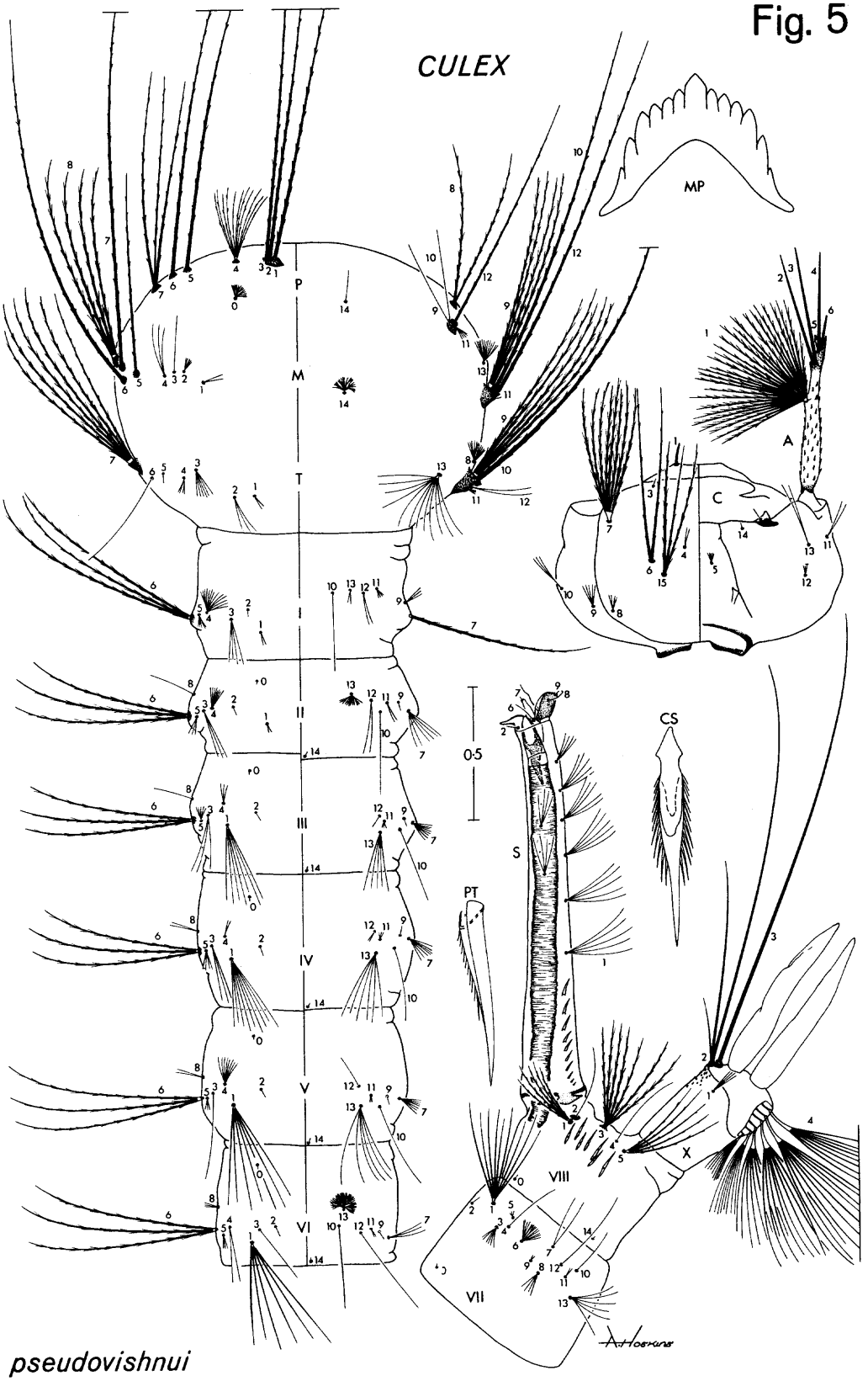
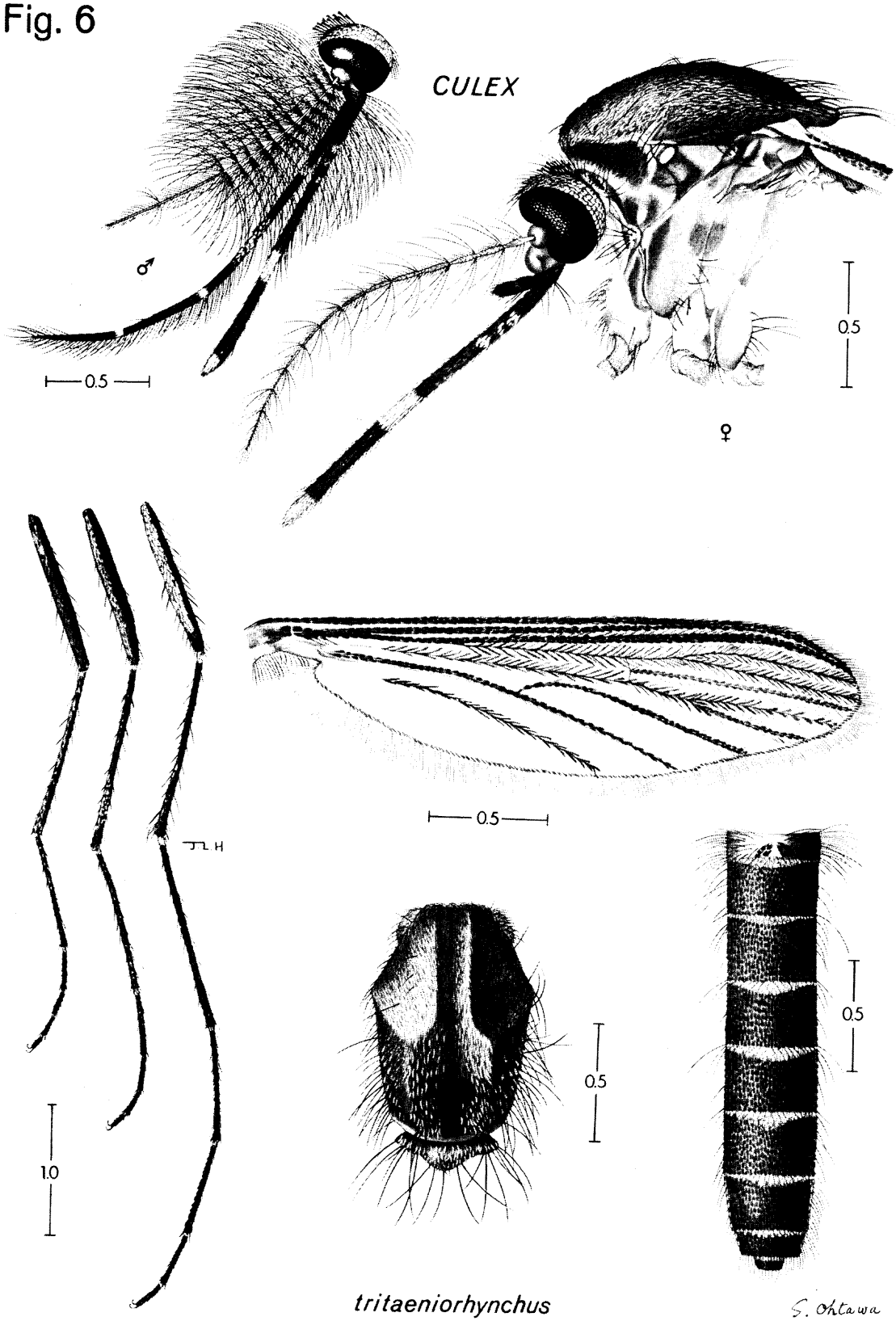


pseudovishnui

Fig. 6



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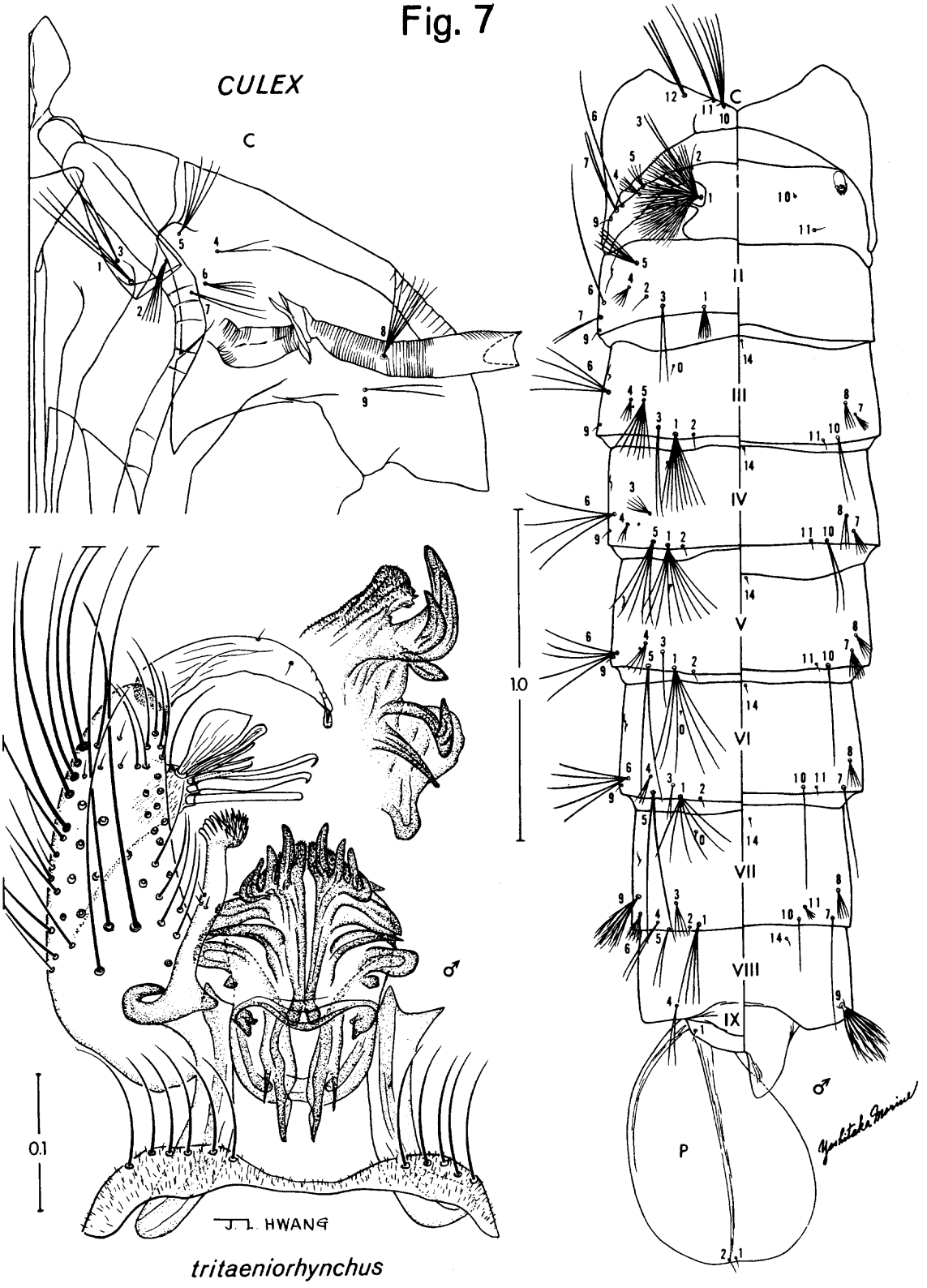
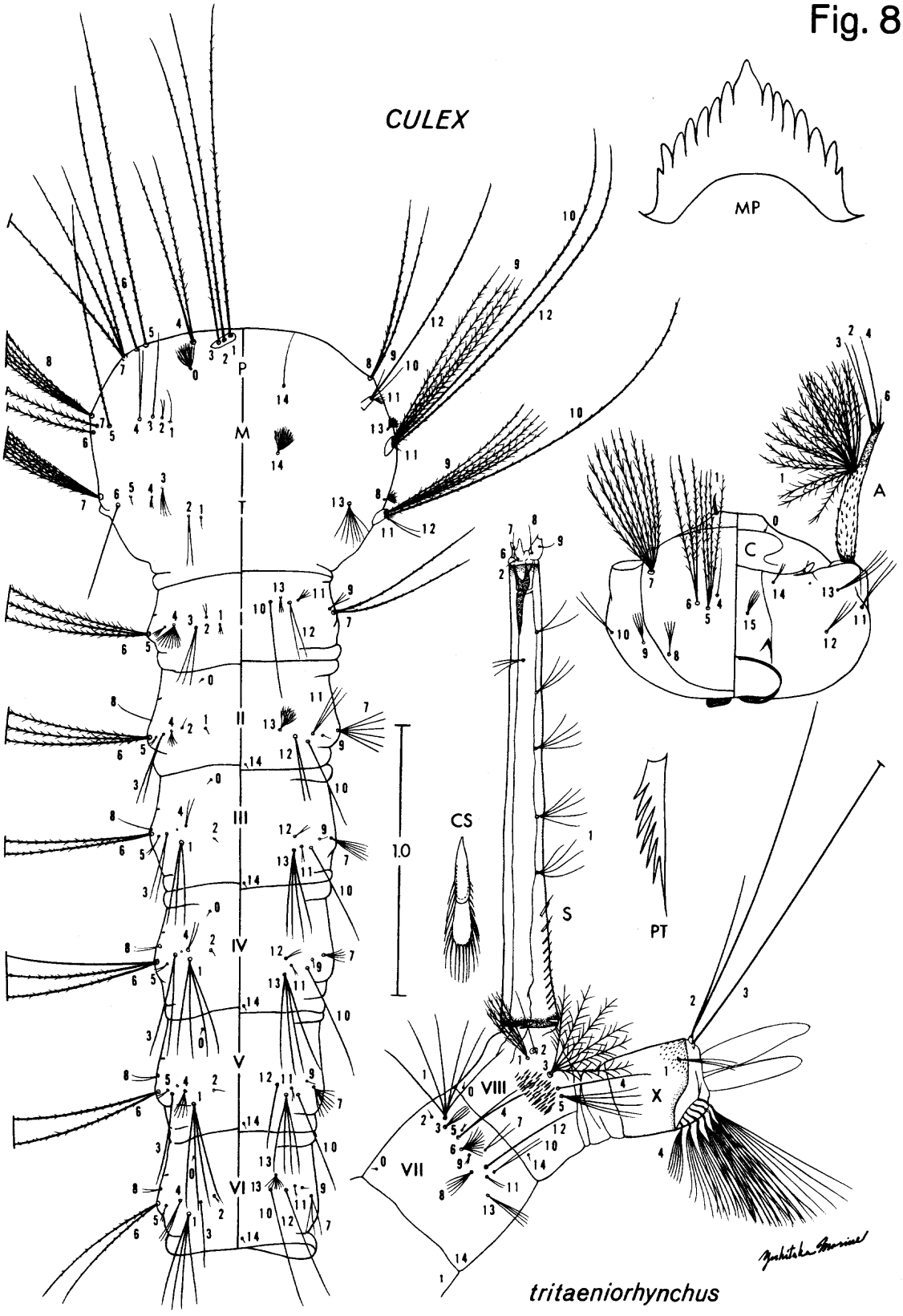


tritaeniorhynchus

Fig. 8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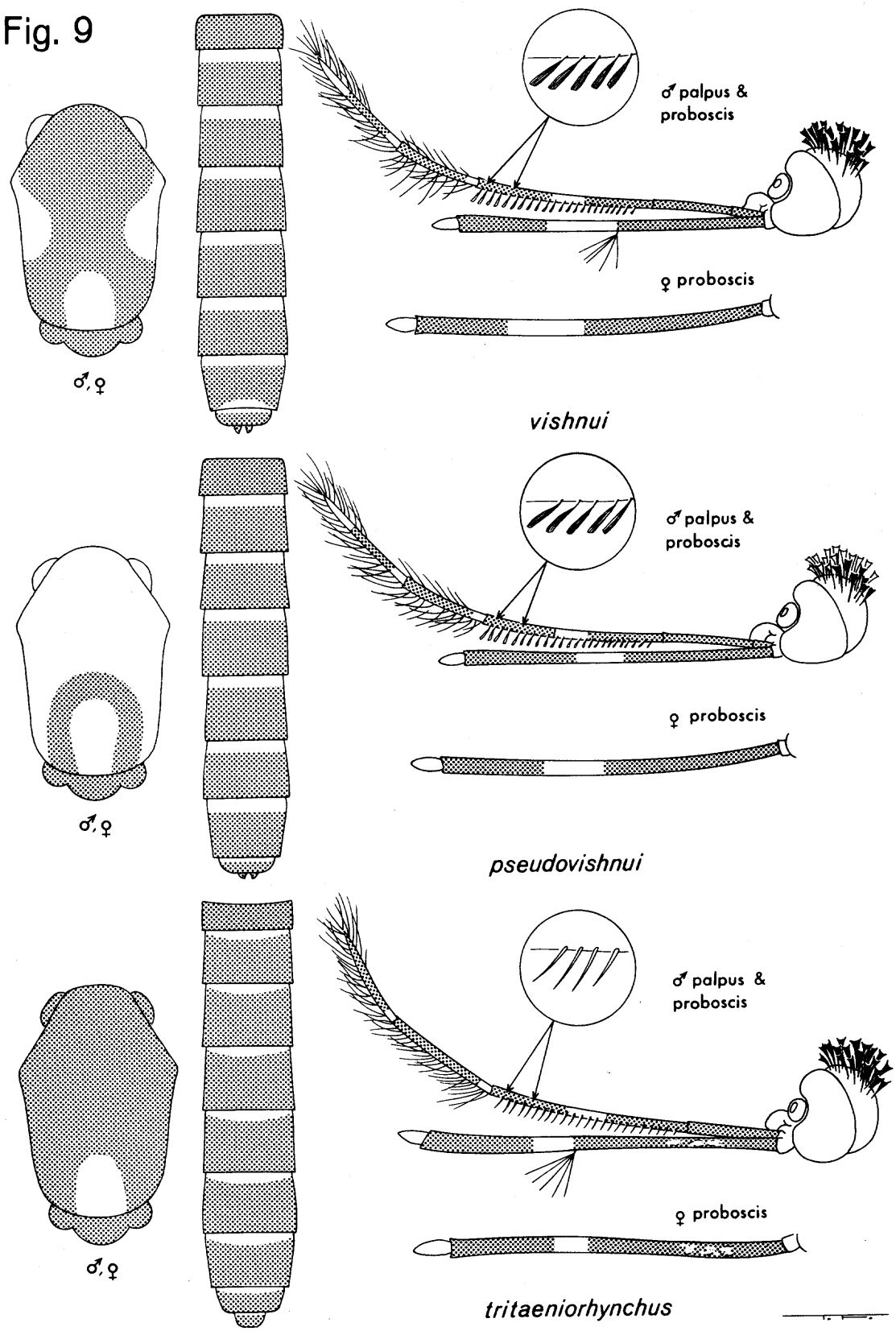
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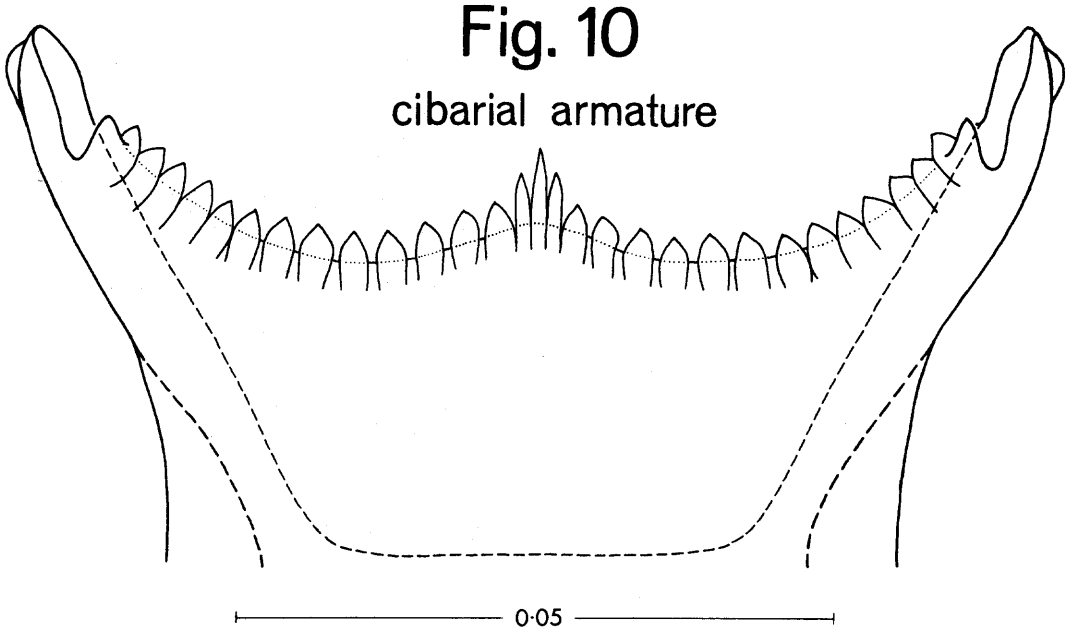
Fig. 10

cibarial armature



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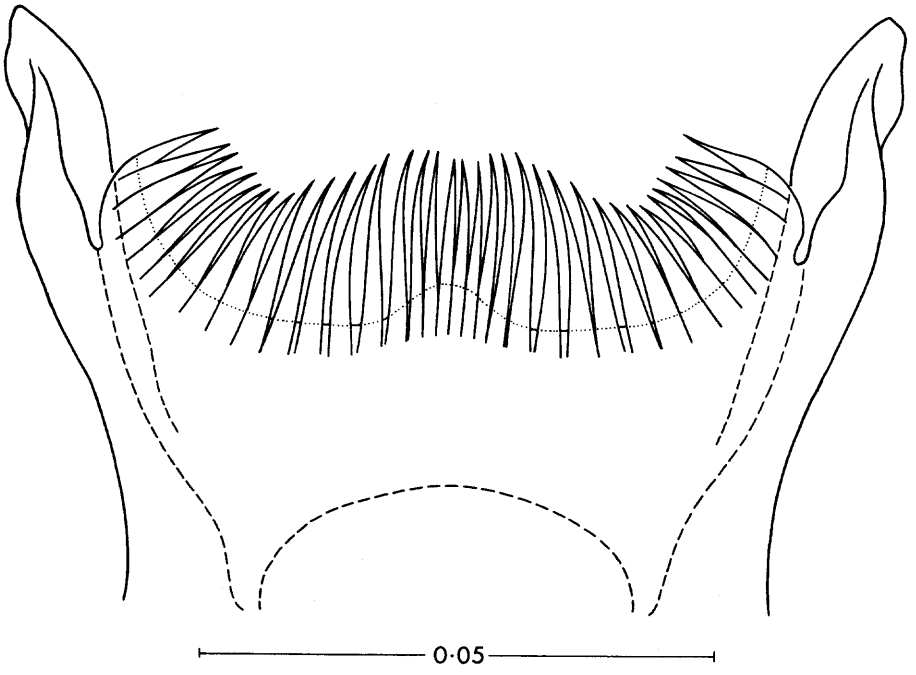
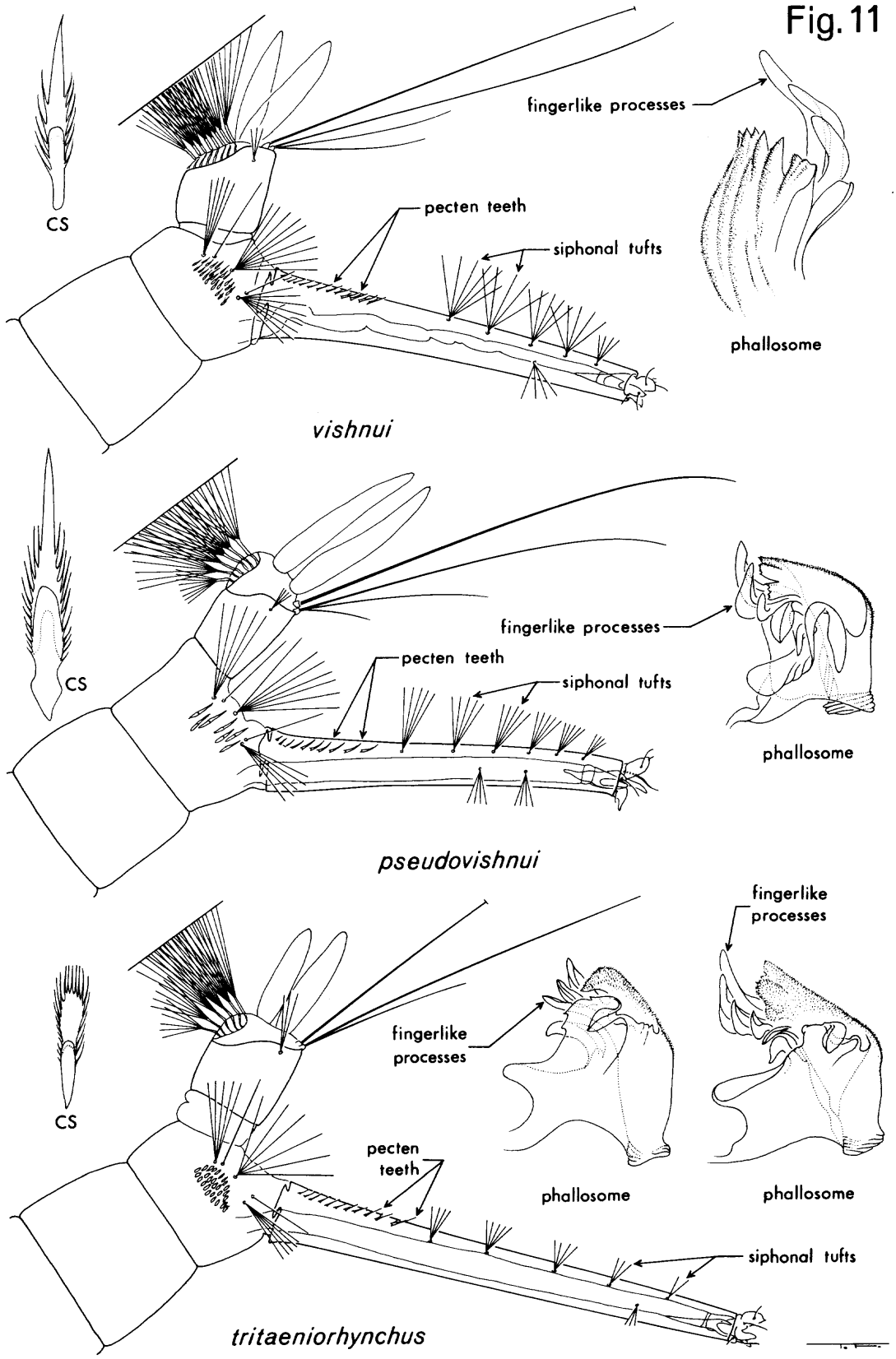


tritaeniorhynchus

Fig. 11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